AUTOMATED DECISION AID SYSTEM FOR HAZARDOUS INCIDENTS (ADASHI) – AN INCIDENT RESPONSE AND TRAINING TOOL FOR CHEMICAL/BIOLOGICAL HAZARDS

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INTRODUCTION

Defense Secretary William Cohen has long expressed concern about the threat posed by weapons of mass destruction and the country's vulnerability to an attack on its own soil. In 1997, Cohen commented that the threat posed by the proliferation of such weapons, is "the greatest threat that any of us will face in the coming years". A year earlier, Congress passed the Defense Against Weapons of Mass Destruction Act, which designated the Department of Defense as lead agency for responding to an attack by terrorists using chemical or biological hazards. As a result of the law, known as the Nunn-Lugar-Domenici Act, the Defense Department created the Domestic Preparedness Program to train local and state officials most likely to be first responders in the event of such an attack.

Emergency responders and incident command personnel must make rapid decisions in life-saving and life-threatening situations. When dealing with terrorist incidents involving suspected or known chemical-biological hazards, these personnel require training in the use of and rapid access to technical knowledge to properly react to these types of hazardous events.

The integration of disparate functional responders such as medical and decontamination specialists, hazardous material (HAZMAT) teams, and explosive ordnance disposal (EOD) teams requires substantial planning, coordination and practice. This dependency and interdependency of multiple operational functions are mapped out in Figure 1. The need exists to integrate hazard projections and challenges to enable the production of requirements.

Current reference documentation and formal training curricula are singularly structured to the point of being "stove-piped". For example, decontamination processes and physical protection requirements are not normally linked but are taught as independent functions. In practice, however these processes are integrally linked. The need exists for a logic base that tactically relates these functional elements together based on rapidly collected and identified information as responders assess the situation.

The Automated Decision Aid System for Hazardous Incidents (ADASHI) is a portable, computer-based decision support/training system for improving the response to a hazardous incident by military and civil responders. ADASHI is designed to function on laptops and desktop computers and can be used at the site by the incident commander (IC) or at higher echelon operation centers. The tool has the capability to support individual and collective training at detachment or team locations or even at a responder's home. This system integrates the specific technical functions required to manage a hazardous incident

Report Documentation Page			*Form Approved* *OMB No. 0704-0188*
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1. REPORT DATE **01 JUL 2003**	2. REPORT TYPE **N/A**		3. DATES COVERED **-**
4. TITLE AND SUBTITLE **Automated Decision Aid System For Hazardous Incidents (ADASHI) An Incident Response And Training Tool For Chemical/Biological Hazards**			5a. CONTRACT NUMBER
			5b. GRANT NUMBER
			5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)			5d. PROJECT NUMBER
			5e. TASK NUMBER
			5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Edgewood Chemical Biological Center US ARMY SBCCOM Edgewood Aberdeen Proving Ground, MD 21010**			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**			
13. SUPPLEMENTARY NOTES **See also ADM001523., The original document contains color images.**			
14. ABSTRACT			
15. SUBJECT TERMS			

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**10**	

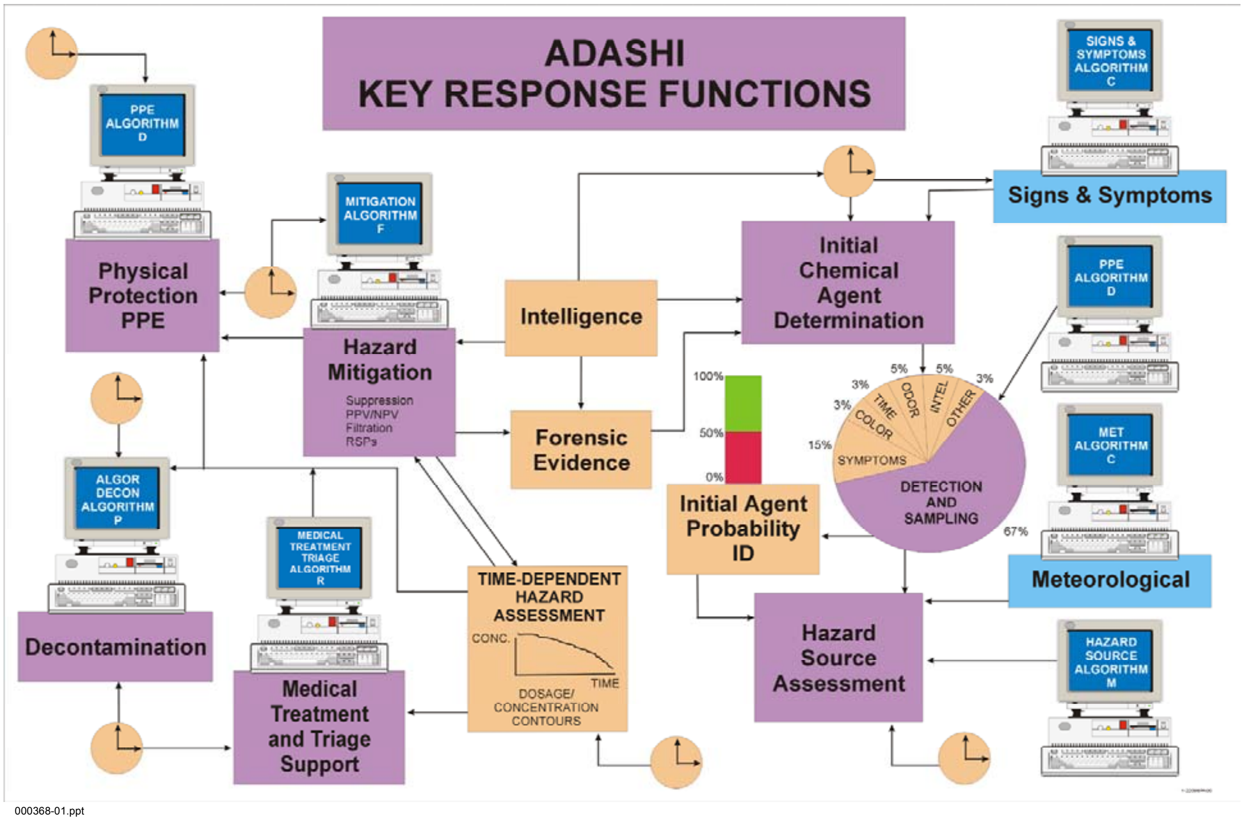

Figure 1. Key response functions as an integrated framework.

involving chemical or biological hazards. Those functions include:

- Initial hazard assessment,
- Hazard source analysis,
- Physical protection,
- Decontamination methods,
- Hazard area prediction,
- Detection planning and sampling,
- Medical treatment, and casualty estimation criteria,
- Hazard Mitigation.
- Specific functional inputs are integrated with decision criteria.

The initial development has been on Chemical incidents. Approximately 50% of the required functionality has been established. Other Weapons of Mass Destruction (WMD) categories, such as response to biological agents are in the formative stages of development.

ADASHI is designed to automatically monitor the essential aspects of an event, whether it be a "What if" simulated event for training purposes or a real event. This automated time-critical and time-dependent control and monitoring function is accomplished using detailed computer algorithms and data processing architecture requiring embedded expert assistance logic and multivalent neural processing techniques. These neurofuzzy algorithms act on immediate “human“ inputs (i.e. imperfect, less than optimal) linguistic variables. Automated multifunction tracking and monitoring is valuable as a training tool where individual data inputs can influence a WMD training scenario outcome. The system can then help determine the scope of operational alternatives available and query the trainee using direct questions,

memory prompts, etc. to help in making an informed decision. The trainee must then select his actions from the options in order to mitigate the effects of the incident. The database structure alleviates the training burden by offering in electronic format disparate reference material. Team leaders and members can perform “trial and error” learning and build confidence and expertise in different learning environments.

ADASHI is to be utilized as an "over the shoulder" decision-support system to aid incident commanders by processing the multivariate input data and providing critical information to the system user in a high-stress environment. This system can also be employed at higher echelons, such as operations centers or 911 dispatch centers, to aid in community response resource management.

In the remainder of this paper, general design features will be discussed then the training overlay will be presented. Finally, an example of a training scenario will be worked through.

DESIGN CONCEPT

The graphical user interface (GUI) enables the user/trainee to identify the operational situation by entering information peculiar to their circumstances. There are two types of data that are processed – high confidence data such as time, meteorological conditions, and physicochemical characteristics, and other softer/fuzzier data originating from a variety of human sources such as 911, other initial responders or victims at the scene. The user interface (Figure 2) exists solely to collect and present information with all algorithms implemented as separate objects. The intent is to use as much non-numerical or linguistic variable information input as possible. The logic here is that inputs during the chaotic notification and response phases of an incident will be fuzzy anyway. Therefore, it makes sense to process this less than optimal information to “get in the ballpark”, as far as how an incident is progressing.

The user will have direct access to memory aids and check-off lists or can make queries of the

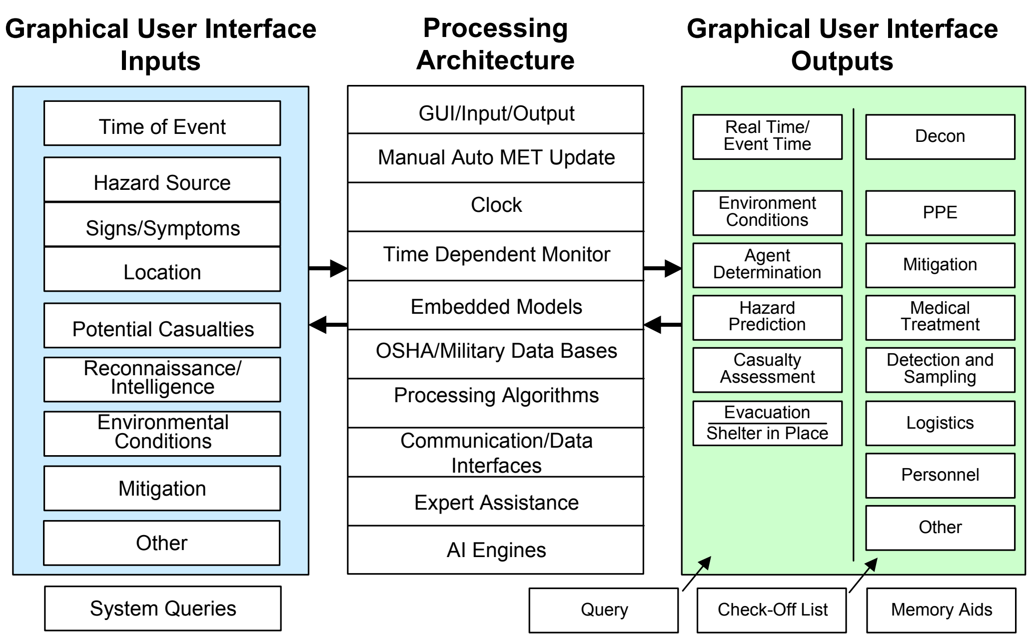

Figure 2. Input and output flow.

ibraries contained within this architecture. The user will make the choice up-front as to whether to use the tool as a training instrument or in the decision mode. In particular, if the tool is used in training, the software is configured to ask questions of the trainee. For example, what response to take and then compare that to "the suggested school solution". When the tool is applied in the decision mode, the suggested responses are provided as output from the behind-the-scenes computations. As an example in the proof of principle version, the incident responder is presented with a checklist of potential symptoms experienced by casualties as a matter of time from agent exposure and observable material properties (signs). The processing software then "determines" the probable causative agent based on the symptoms and related "signs" selected from the checklist, or indicates an unknown agent. Appropriate physical properties are then pulled-up from the agent characteristic library and used in computing time-dependent vapor concentrations following agent dissemination in a ventilated enclosure. In the training instrument mode, the user could be asked to identify the likely agent based on the selected set of symptoms defined in the established training scenario or vignette.

Existing hazard prediction models will be used where possible. For outdoor incidents, the user can choose from either the Personal Computer Program for Chemical Hazard Prediction (D2PC); the Vapor, Liquid, and Solid Tracking (VLSTRACK) or the Hazard Prediction Assessment Capability (HPAC). **However, it is predictable that many terrorist incidents will occur below the threshold of these models.** Prediction tools that function within urban sectors or neighborhoods will be included. Those readily available will be evaluated for use. Currently, an enclosure model InDeVap [Indoor Evaporation Model] is available for indoor release of hazardous chemicals. Other PC-based indoor models will be evaluated for applicability. A multiple domain hierarchy is required for hazard prediction models and terrain databases. The Hazard Source Assessment processor will integrate a variety of hazard prediction models such as HPAC, D2PC, VLSTRACK, InDeVap, etc. As a result, a time-based assessment of environmental hazard dosage (

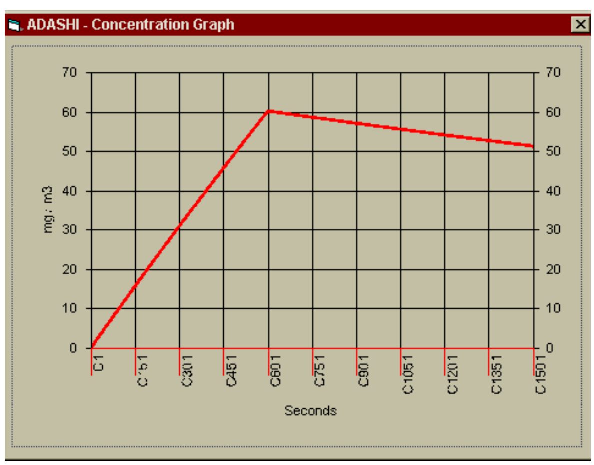

Figure 3. Time-based dosage assessment.

Figure 3) can be presented. ADASHI is configured such that similar or identical input icons will drive the selected prediction model. Outputs can be presented as an integrated time/concentration contour plot.

AGENT SIGNS AND SYMPTOMS

The initial signs and symptoms are very important in order to focus on the true nature of the hazard and eventually its identification. In many cases, a combination of signs and symptoms are so specific, that it suggests what has happened and what detectors will best verify the presence of a particular hazard. In the initial prototype, a time-based listing of symptoms for exposure are used to determine the chemical hazard. A drop-down window listing the **symptoms** allows the user to "check off" (indicate) prevalent symptoms from incident casualties and observable signs of the hazardous material. This module tracks both the exposure time, onset time to effects and symptoms; and uses the signs and symptoms combination to make an estimate of the type of hazard involved in the incident (i.e., nerve agent, tear gas, etc.).

Through the Expert Assistance algorithm and database comparisons, a more refined determination of the most likely agent within the identified agent type will be processed. This module is periodically updated as survey teams provide information, thereby, increasing the accuracy of the prediction.

METEOROLOGY

A Meteorological (MET) Status Screen can be pulled-down by the incident commander or trainee to review a range of MET conditions to include temperature, relative humidity, wind speed, wind direction. A rapid change in wind direction can adversely affect the staging of hot zone/warm zone operations, location of decon and casualty estimation sites, and access/egress routes. For example, note that warm and cold zone operations need to be upwind of the hot zone area

The manual or automated tracking of meteorological/weather conditions from local weather tracking stations such as airports or news stations is used as input. Information can be automatically downloaded from the Internet or via cell phone connections. Micrometeorological (MICROMET) conditions can be monitored at the incident using remote meteorological stations (sentries) that automatically track environmental conditions and send data to the emergency operations center.

EMERGENCY DECONTAMINATION AND CASUALTY ESTIMATION

Tracking the process of incident site decontamination and casualty estimation is an overwhelming task for the chemical biological (CB) incident commander. It is a very labor intensive and chaotic process that needs careful managing in order to be successful. In the training mode, the trainee will be challenged with decisions and operations that must be performed in a timely manner in order to be successful. In the decision-aid mode, the system will postulate the probable scenarios based on the potential number of casualties, the kind of agent employed, the dispersion source characteristics and the specific venue where the incident occurred. This will involve logical integration of the Agent Identification (Signs &

Symptoms), Hazard Assessment, Clock/Time and Decon/Casualty Estimation processes.

Inputs into this processor will come from pull-down menu icons that will query the trainee or the incident command user on the characteristics of this particular event. Time of incident, MET conditions, venue and hazard source information, and signs and symptoms will be called up from previous entries to verify that these data are still pertinent. Monitoring weather is very important, especially if temperatures fall below 50 degrees F, due to problems with hypothermia given the amount of water used in a typical decontamination process. This process will provide estimated levels of casualties. This projection of casualties is based upon the START TRIAGE system for casualty estimation. A dynamic tracking tool as a pull down option for the trainee or IC is provided to monitor this multifaceted procedure (Figure 4).

Outputs from the above processor will include emergency decon station (EDS) casualty throughputs (EDS rate) and will monitor both ambulatory and non-ambulatory EDS. ADASHI will assist the trainee or the IC in determining whether decon or casualty estimation rates are adequate; or suggest establishing additional EDS corridors with assistance from existing local support agreements.

TIME/CLOCK MONITORING AND TRACKING

An integrated Time Monitoring/Tracking module is a key element in the architecture for ADASHI. This algorithm will be linked to all processes that are time-dependent, or require time tracking of some sort.

Incident tracking for the EOC or the IC, will include actual time monitoring or Real Time, the estimated time the incident occurred, and the elapsed time since the incident occurred. Time tracking will also be embedded into the Personal Protective Equipment (PPE) algorithm. This will allow emergency responders to coordinate proactive personnel accountability process that will track entry/ exit times in the hot and warm zones. The PPE module will also monitor over time what activities these responders are performing and track their potential exposure to environmental hazards based on the particular protective ensemble that is worn.

Many table-top or field training exercises develop an assessment or profile as to how well emergency responders are making decisions; and how well they are actively implementing the training they have taken in this new emergency area. What is not assessed well in the aforementioned training sessions is an active time-dependent measure of their performance, both at the tactical and the incident command levels.

HAZARD MITIGATION PROCESS

In many cases, actual or potential threats using CB dispersion devices can be mitigated with an effective, hazard-mitigation reduction protocol. This will require both the explosive ordnance technician (bomb tech) and the hazardous material technician to work hand in hand as an integrated team to reduce the probable airborne hazards from a variety of hazard sources. These sources (or devices) can be as simple as a toxic spill similar to what occurred in Tokyo with the Aum Shinrykyo cult or much more complex with very efficient dispersion systems.

This module will include practical information on how to approach suspect devices, how to mitigate their dispersion effects and how to suppress and contain the hazards to preclude long-term airborne exposure. In many cases these techniques are already used at the technician level by emergency

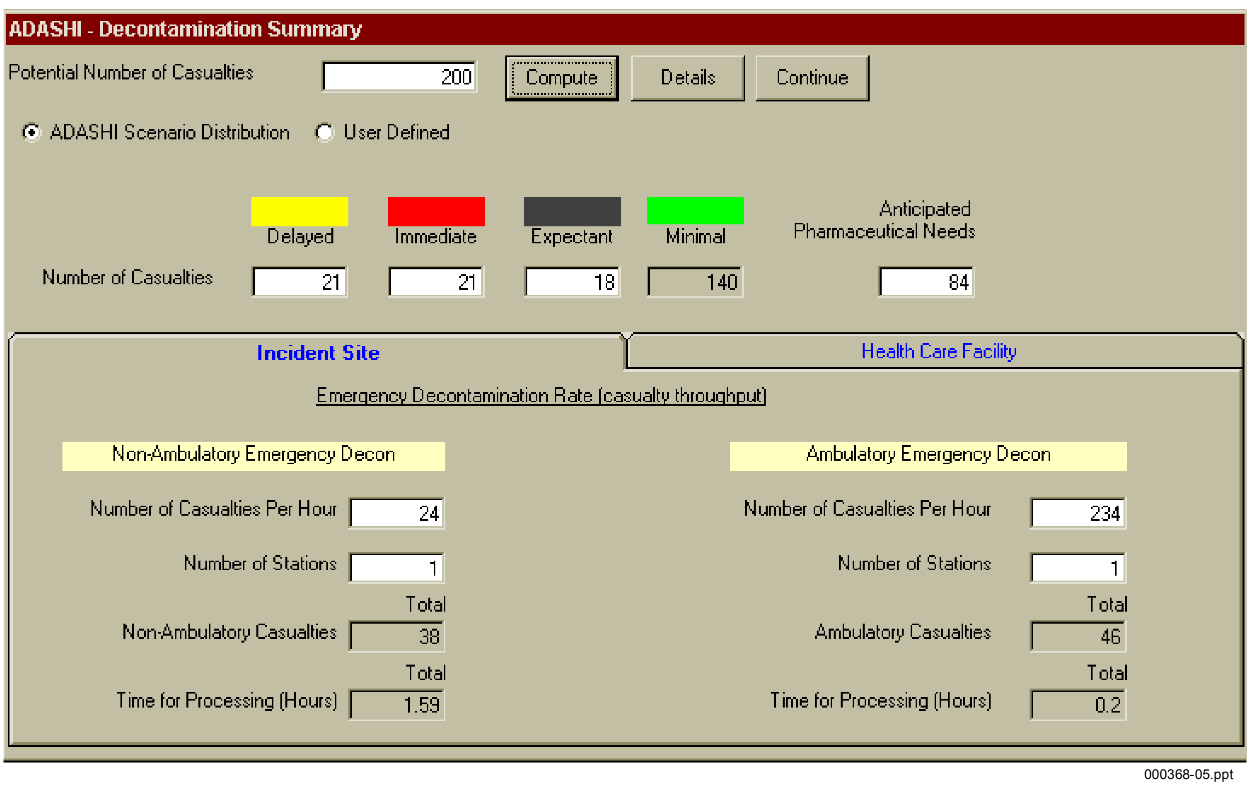

Figure 4. Casualty distribution and applied decontamination time-based effectiveness.

responders across the country. It will also present to the trainee or the emergency responder the logic behind how hazard sources are generated, which sources are of concern, and what venues are more susceptible than others are. After the source characteristics are understood, the deployment of hazard mitigation and containment techniques will be described and situations presented where utilization of

these systems makes sense. A trainee will be queried on what alternatives could be used in particular hazard settings to verify the individual's competency level.

CASUALTY ESTIMATION, TRANSPORT AND MEDICAL TREATMENT PROCESS

The Casualty Estimation, Transport and Medical Treatment process is an integrated sequel to the Decon and casualty estimation process. These processes are intimately related in a CB incident. The Casualty Estimation, Transport and Treatment component expands the knowledge of the trainee in the training mode by prompting and presenting in a time-dependent sequence the myriad roles and responsibilities of the at-site and local health care provider. These responsibilities, which are critically time-dependent include:

- Emergency decontamination and casualty estimation actions at the local clinics and hospitals. The supporting algorithm receives/transmits two-way feedback between the Signs and Symptoms Algorithm. This will allow for enhanced assessment of the released hazardous agent and how to provide more effective treatment.

- Post-incident actions will include the performance of medical services as necessary, both at the site and at local hospitals and clinics. Other prompts will direct the user to recommended casualty estimation procedures and emergency decontamination for the self-referred or incident-transported casualties reach the treatment area. It will assist in the set-up of coordination measures for contacting additional medical personnel to bolster the response to a CB mass casualty incident.

TRAINING OVERLAY

Automated multifunction tracking and monitoring can be used as an effective interactive training tool. A trainee can structure a hazardous incident scenario through his inputs on the GUI. The scenario presented then requires specific actions to mitigate the effects of the incident.

ADASHI's processors can then determine the scope of tactical alternatives available and query the trainee using direct questions, memory prompts, etc to help in making an informed decision (Figure 6).

The training component can serve as an adjunct to didactic and practical application training to test the concepts and methodologies the trainee has learned. The trainees can enhance their mastery of the various tactical issues in responding to these CBR incidents by working through a bank of queries set up to test the capabilities of these responders. This programmed learning sequence may use "canned" scenarios or the student may opt to create his own. The learning mode will focus on optimizing situational awareness and provide queries and/or guidelines as to what actions might be taken dependent upon the circumstances. The system can be set up to work in a graded or pass-fail mode.

The system can be set up to track data during an event allowing for manual as well as automatic updating of the situation. Prompting and querying will automatically require prompt response by trainees, thereby enhancing their real-time decision-making prowess. Employing fuzzy logic processing, ADASHI interacts with the student in moving toward a general increase in competence and understanding. If the student is very weak, based on the level of monitored improvement, the system will bring up fundamental concepts as a programmed learning tutorial. If the student has displayed more competence, it will "nudge" the student along toward a general level of competency (Figure 5).

This training component will be an integrated and consistent system using directly the operational decision-aid mode processing of this system. All active processing algorithms are identical to the operational mode so that a real-time, realistic scenario is presented to the trainee in the training mode.

Training decisions and prompts are embedded into a flow-processing matrix. The direct expert logic used in the decision- aid mode is employed so the trainee can gain experience, and then can use the system as a support tool for actual operational venues or incidents. The training overlay can be driven as if it were accepting decision inputs identical to those used in the operational mode.

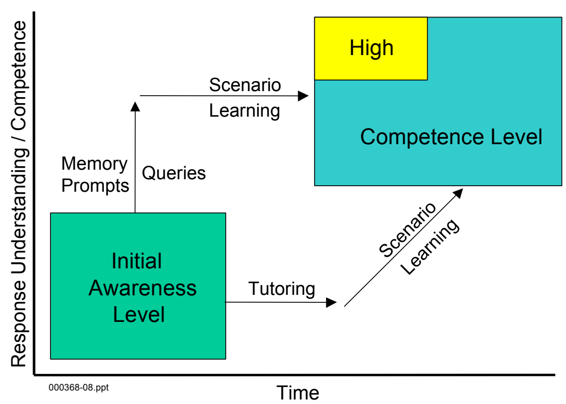

Figure 5. ADASHI learning concepts.

Other templates can be constructed in this training mode to accommodate a variety of operational users to include – US Army Tech Escort Unit, National Guard Raid Teams, United States Marine Corps (USMC) CBIRF, HAZMAT responders, EMS responders, Explosive Ordinance Disposal (EOD) bomb technicians and hospital providers.

Also in this mode, individuals at home can use ADASHI or it can be used in operational team training settings. This training can be accomplished using a distributed learning network or over the Internet. It will be an interactive system coaxing, monitoring and reminding the trainees of the particular situation they are in. As aforementioned this will be accomplished using a comparison algorithm to track trainee responses and compare them with expert situational alternative.

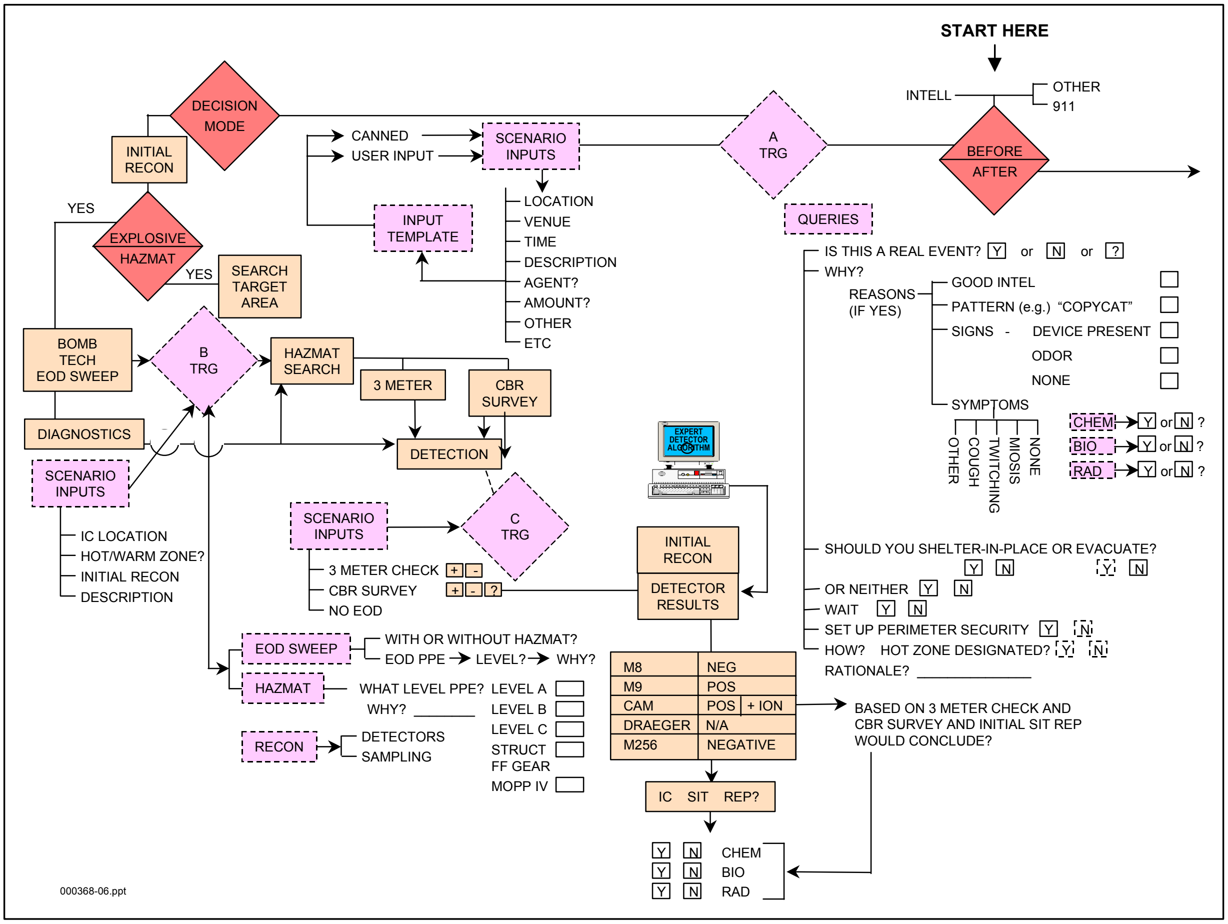

Figure 6. Training overlay for an initial assessment.